5.1 - BUFFER ESTABLISHMENT, REPLACEMENT AND RESTORATION

PURPOSE:

The purpose of this chapter is to provide guidance for the establishment, replacement or restoration of the 100-foot wide buffer required by the Chesapeake Bay Preservation Act. This vegetation needs to be effective in performing the required functions of retarding runoff, preventing erosion, filtering non-point source pollution from runoff (assumed to achieve at least a 75 % reduction of sediments and a 40% reduction in nutrients). In order to best achieve these goals, a mixed community of vegetation, including trees, understory, shrubs and groundcover imitating an undisturbed riparian forest, is considered the appropriate vegetated buffer.

This chapter suggests procedures for establishing vegetation to replace or restore vegetation removed from a buffer or to establish a new, forested buffer. Different circumstances will require different responses. A buffer established on an existing agricultural or silvicultural parcel requires different methods than merely restoring a few plants that have been removed for purposes allowed by the Bay Act.

REGULATIONS:

§ 9 VAC 10-20-130.3. states that:

"…a 100-foot wide buffer area of vegetation that is effective in retarding runoff, preventing erosion, and filtering non-point source pollution from runoff shall be retained if present and established where it does not exist."

§ 9 VAC 10-20-130.3.a. states that:

"The 100-foot wide buffer area shall be deemed to achieve a 75% reduction of sediments and a 40% reduction of nutrients."

§ 9 VAC 10-20-130.3.b. states that:

"Where land uses such as agriculture or silviculture within the area of the buffer cease and the lands are proposed to be converted to other uses, the full 100-foot wide buffer shall be reestablished. In reestablishing the buffer, management measures shall be undertaken to provide woody vegetation that assures the buffer functions set forth in this chapter."

DISCUSSION:

There are several situations that require replacement plantings:

1) Conversion of agricultural or silvicultural land to another land use, requiring buffer reestablishment;
2) Restoration of vegetation in a buffer where forestry best management practices dictate the removal and replacement of vegetation (such as trees and shrubs overwhelmed by invasives like kudzu, or 50% or more of the existing plant material consists of invasive species) for the health of the buffer or for shoreline erosion control;
3) Replacement of vegetation that has been removed to achieve a sight line or access path or for woodlot management.
4) And for replacement of illegal excessive removal of vegetation (also see Chapter 7-Violations).

Reestablishment of a forested buffer is required when an existing agricultural or silvicultural parcel of land is changed to another land use. Under the Bay Act, silvicultural activities in the Chesapeake Bay Preservation Areas are exempt, provided that the operations adhere to the water quality protection measures prescribed by the Virginia Department of Forestry. The Department of Forestry requires establishment of a Streamside Management Zone (SMZ) a minimum of 50 feet in width, measured from the top of the stream bank. The 50-foot SMZ can be a managed forest, which means that up to 50% of the basal area or up to 50% of the forest canopy area can be harvested.[1]

Land in agricultural use often has less than 100 feet of woody vegetation in the buffer. When converted to another land use, woody vegetation must be replanted.

Agricultural activities can encroach within the landward 75 feet of the 100-foot wide buffer area when best management practices are used to address erosion control, nutrient management and pest chemical control. This may leave as little as 25 feet of vegetated buffer. Under both agricultural and silvicultural land uses, the land may have less than 100 feet of buffer remaining in woody vegetation at the time of its conversion to other uses. Whatever area of the 100-foot wide buffer is not covered with woody vegetation at the time the use is converted, must be planted so as to achieve the required buffer width and functions, returning the area to a condition

that closely resembles a pre-disturbance state.

Restoration of a buffer may also occur when a large amount of vegetation has been removed to maintain vegetation health or for erosion control projects involving grading. Restoring a riparian forest buffer requires planting not only canopy trees, but the other trophic layers as well. A forest is a complex ecosystem incorporating canopy trees, understory trees and shrubs, a ground layer of herbaceous plants and leaf litter. Establishing a community of plants similar to those already existing in an area requires duplicating the density, spacing, and distribution of the particular species that naturally occur. The most important part of a restoration is establishing the canopy, since that is critical to the microclimate of the community.[2]

Replacement of vegetation must occur when individual trees, shrubs or groundcover are removed to provide a reasonable sightline, to create an access path, for general woodlot management or for forestry best management practices. Replacement generally should involve only small amounts of vegetation and provide for replacement of trees, shrubs and groundcover. A Vegetation Replacement Table, with suggested replacement rates may be found in this chapter and in *Appendix D*.

In order to understand the reasons for restoration, replacement or reestablishment of a buffer, it is important to understand what an undisturbed natural buffer is and does. The next section describes what characteristics are typical of a native forest community.

NATIVE FOREST COMMUNITY

The best buffers are those that share the traits of natural, undisturbed, forested vegetative systems. A natural forest would contain a dense vegetative cover of native plants, groundcover and leaf litter, would have undisturbed soils and would sustain a healthy microbial community.[3] "Forests provide the greatest range and number of potential environmental benefits…"[4]

Benefits that are either enhanced by or require a forest are; (1) protection from stream bank erosion, (2) protection of associated wetlands.[5] (3) increased removal of nitrogen, (4) Ground water recharge (5)reduced downstream flooding, (6) thermal protection, (7) enhanced potential for stream restoration, (8) reduced watershed imperviousness, (9) food and habitat for wildlife, (10) food and habitat for fish and amphibians, (11) provision of corridors for

habitat conservation, (12) foundation for present or future greenways, and (13) increased urban/suburban property values.

When evaluating the effectiveness of a buffer, the soils, slopes, hydrology, and vegetation all play a part. An increase or decrease in any of the factors comprising an effective pollutant removing buffer may compromise its ability to fully accomplish its role in maintaining water quality. "The key to maintaining good forest watershed conditions lies in proper management of the forest floor. Even when disturbed, forest litter effectively reduces soil movement and excessive surface runoff. With time, more water will soak into the soil as organic matter blends into the surface soil. Of course, the forest floor must be protected from additional disturbances to accomplish these improvements."[6]

A natural forest community buffer, one that effectively retards run-off, prevents erosion, and filters non-point source pollution would have the following characteristics:

A. Forest cover would be dense and contain shade trees, understory trees, shrubs and either groundcover or a deep layer of leaf litter and humus.
B. Soil would be permeable with high organic content, not highly sandy.
C. Slopes would be less than 5%.
D. Overland flow would be less than 150 feet before reaching the buffer.
E. Velocity of run-off would be less than 1.5 ft/sec.
F. Water would pass into the buffer in sheet flow, not concentrated flow.
G. There would be a high water table.[7]

Not all riparian buffers have each of these preferred characteristics, yet not all of the characteristics have to exist to achieve a reduction in sediment and pollutants. Modifying some characteristics, such as slope and distance of overland flow, may not be possible, but other factors may be mitigated. Adding vegetation and mulch can help increase soil permeability. Over time, roots with their associated microbes and insects break down leaf litter and other debris adding the organic material to the soil. A thick layer of mulch on top of the soil can add organic matter as well.

One aspect of a forested buffer that can be replicated is the density and proportions of the types of plant materials found in a

typical riparian or estuarine situation. The following table shows the typical mean densities of three classes of mid to late successional stands in the forests of the Coastal Plain and a total basal area found in both riparian and estuarine forest stands from an unpublished data gathered by the Department of Conservation and Recreation, Division of Natural Heritage. The mean densities of the different materials may be used as a guide when establishing goals for restoration, replacement or establishment of riparian buffers.

The above table indicates that, proportionally, an undisturbed forest will have approximately 25% canopy trees, 25% subcanopy trees and shrubs and 50% shrub/saplings. While the total count of stems per acre varies from riverine to estuarine stands, the basal area remains similar.

TYPICAL STOCKING RATES OF VIRIGNIA FOREST STANDS			
	All Stands **MEAN**	Riparian Stands **MEAN**	Estuarine Stands **MEAN**
Shrub/Sapling[a] Density (stems/acre)	269.6	199.2	340.0
Subcanopy[b] Density (stems/acre)	110.4	83.3	137.5
Overstory[c] Density (stems/acre)	100.8	94.2	107.5
Total Density (stems/acre)	480.8	376.7	585.0
Basal Area (ft^2/acre)	228.7	239.5	217.9
a - shrub/sapling stems range from 1 to 4 inch dbh (diameter breast height - 4.5 ft.); **b** - subcanopy stems range from 4 to 10 inches dbh; **c** - overstory stems are equal to or greater thatn 10 inches dbh.			

Table 5.1. Stocking rates in 24 forest stands of riverine and estuarine buffers.[8]

DEVELOPMENT OF A BUFFER ESTABLISHMENT OR RESTORATION PLANTING PLAN:

Analysis

An analysis of the existing site characteristics, vegetation and land use may be necessary to choose the best method of buffer establishment and appropriate plantings. An analysis of the site should include the following information:

Vicinity map

Shows location of property; relationship to adjacent water body and natural resources.

Soils classifications

Soil survey information can be obtained from the local Natural Resources Conservation Service office or local Soil and Water Conservation District offices. The classification of the soils on site will give information regarding slopes, soil color and texture, soil horizon, depth to bedrock, permeability, runoff potential, moisture capacity, and other information related to woodland management. (For a more in depth explanation of soils see Section IV of *The Chesapeake Bay Riparian Handbook*.)

Seasonal High Water Table

Information on the typical depth to the Seasonal High Water Table can be found in the soil survey, however a soil probe can give a quick determination to depth by observation of soil wetness or soil mottling. This is important for choosing plants that will thrive in the existing moisture conditions.

Soil chemistry (from soil test)

Soil samples can be analyzed by by the Virginia Tech Soil Testing Laboratory to determine the available nutrients in the soil. Call your local Virginia Cooperative Extension Office for instructions and a Soil Sample Box. A routine soil test kit will cost $7.00 (as of Spring 2003) and the results include recommendations for soil improvement, if necessary.

Topography

Topography will give the slope and aspect of the parcel within different areas of the buffer. Slopes facing south or west with more sun exposure are more likely to have lower moisture levels, while

north and eastern slopes and stream reaches are less exposed and likely to have a higher moisture content. Local topography can create anomalies in the soils and moisture particular to a site.

Floodplain

Those areas of the buffer that are within the flood-plain need to be identified so that plants tolerant of periodic inundation can be chosen for that area.

Location of water features, rock outcroppings, steep bluffs, existing vegetation and other significant features.

These features will affect the location of plantings. Significant rock outcroppings will prevent plantings. A bluff may require herbaceous as well as woody plantings to prevent erosion. A significant or noteworthy canopy tree, or forest grouping should be shown so the planting plans can take them into consideration.

DEFINITIONS:

Canopy tree: a tree that reaches 35 feet in height or larger when mature

Sub-canopy: can be an immature canopy tree, a stunted canopy tree, or other co-dominant tree or an understory tree

Understory tree: a tree that matures to a height of 12 feet to 35'

Large shrub: a shrub that reaches 10 feet of height or greater at maturity

Small shrub: a woody plant that can reach up to 10 feet of height at maturity

Planting plan

A planting plan should be included in any application for approval, clearly delineating the location of plants removed and plants to replace them. The plan should be at a large enough scale to be legible.

The planting plans should have the following information:

Vicinity map, scale, north arrow

Property owner and address & contact name and number for the person who prepared the plan, if different from owner

Existing vegetation remaining

Proposed location of new plant material

Species, size, root condition (B&B, container, bare root) See Appendix C for an example of a plant list

Planting specifications and details on installation procedures, and protection measures

Maintenance plan & schedule

REPLACEMENT PLANTING:

Replacement planting occurs when small amounts of vegetation have been removed in accordance with The Chesapeake Bay Preservation Act, Section 9 VAC 10-20-130.5.

"Permitted modifications of the buffer area.

(1)Trees may be pruned or removed to provide for sight lines and vistas, provided that where removed, they shall be replaced with other vegetation that is equally effective in retarding runoff, preventing erosion, and filtering non-point pollution from runoff."

And

"(4) For shoreline erosion control projects, trees and woody vegetation may be removed, necessary control techniques employed, and appropriate vegetation established to protect or stabilize the shoreline in accordance with the best technical advice and applicable permit conditions or requirements."

Although the preferred method for developing sight lines or vistas is pruning out the lower branches of trees and trimming shrubs to a height of 3.5 feet (as discussed in *Chapter 3.1)*, occasionally the removal of a few shrubs or trees may be necessary to achieve the desired sightline. Access paths should also avoid trees and shrubs, but may require the removal of vegetation. Under these circumstances, the vegetation must be replaced with woody vegetation or a combination of woody and herbaceous material.

When shoreline erosion control projects result in the removal of vegetation (see *Chapter 3.4*) to install erosion control measures, "…marshes are the natural shoreline vegetation for many of those areas. At sites where marshes are not the natural shoreline, forest buffers can help stabilize the banks."[9] Replacement of vegetation is a necessary part of the shoreline stabilization process and will help keep the shoreline from eroding in the future. Planting woody vegetation on 2:1 slopes is acceptable. However, large species should be kept away from shoreline hardening and BMPs. Trees should also be kept back from shading shoreline marsh vegetation or submerged aquatic vegetation (SAV). Shoreline erosion control projects may involve the removal of large amounts of vegetation as a result of regrading. Should that be the case, the Restoration Tables should be used rather than the Vegetation Replacement Rates table.

Site preparation and ground disturbance for replacement plantings in an existing forested buffer should be minimal. Existing vegetation should be protected from disturbance during planting of new material. Only the area receiving the new planting should be

disturbed. Invasive vegetation should be removed by hand for a circle of at least three feet in diameter for the planting pit. Leaf litter may be raked and redistributed on site. All plantings should be mulched with 3-4 inches of mulch that is kept away from the base of the plant. Mulch group plantings as a single bed.

The replacement material should have the same functional value as the material that has been removed. Since research suggests that forested buffers have a greater pollutant removal capability than grass buffer strips, woody vegetation is the preferred choice for buffer replacement, restoration or establishment.[10] Native plants are preferred for any replanting and should be similar to those in neighboring sites. The plant selection should include all three trophic layers; canopy trees, sub-canopy trees/shrubs and shrub/ groundcover.

For small areas where the number and type of plants removed is known, such as removal for sight lines or vistas where pruning and trimming are the first option, the replacement rate may be derived from the Vegetation Replacement Table below. The removal of vegetation should be minimal, and the applicant can determine in advance the cost of replacement materials. A single small tree cannot be expected to be as effective as a large tree with an expansive root system in retarding runoff, preventing erosion and filtering non-point source pollution from runoff. Therefore, the table reflects replacement values that will begin to achieve equivalent

NOTE!!

Plant materials planted in the buffer **do not** have to be specimen quality plants.

To minimize expense, "B Grade" plants, either containerized or bare root may be allowed.

VEGETATION REPLACEMENT RATES

VEGETATION REMOVED	PREFERRED REPLACEMENT VEGETATION	ACCEPTABLE ALTERNATIVE VEGETATION
1 tree or sapling 1/2"-2 1/2" caliper	1 tree @ equal caliper or greater	**Or** 2 large shrubs @3'-4' **Or** 10 small shrubs or woody groundcover *@ 15"-18"
1 tree ≥ 2 1/2" caliper	1 tree @ 1 1/2" - 2" caliper,or 1evergreen tree @ 6' min. ht., per every 4" caliper of tree removed (ex: a 12" cal. tree would require 3 trees to replace it)	**Or** 75% trees @ 1 1/2" - 2" and 25% large shrubs @ 3'-4' per every 4" caliper of tree removed. (ex: a 16" cal. tree removed would require 2 trees and 1 large shrub) **Or** 10 small shrubs or woody groundcover @ 15"-18" per 4"caliper of tree removed (ex: a 8" caliper tree removed requires 20 small shrubs .)
1 large shrub	1 large shrub @ 3'-4'	**Or** 5 small shrubs or woody groundcover @ 15"-18"

* Woody groundcover is considered to be a woody, spreading shrub that remains close to the ground, to 18" high, such as a shore juniper, *juniperus conferta*. Vines may not be considered "woody groundcover" for the purpose of vegetation replacement.

Table 5.2: Vegetation Replacement Rates

functioning.

RESTORATION

Restoration will occur when large amounts of vegetation have been removed illegally or, as part of shoreline erosion control projects, as mentioned above. Restoration may also occur when, for woodlot management purposes, the majority (50% or greater) of the existing vegetation has been removed because of damage by insects, disease or other factors important to the health of the buffer.

Restoration may also be necessary when fifty percent or more of the vegetation in a woodlot is invasive material that has out-competed or over-run the existing native trees and shrubs. If the invasives cannot be removed by hand, leaving healthy woody vegetation in place, and complete removal of all vegetation is necessary to eradicate the invasives, then restoration of woody vegetation is necessary to maintain a functioning buffer.

For restoration of areas that have been so overgrown with

RESTORATION/ESTABLISHMENT TABLE A

A. ¼ acre or less of buffer

(Up to 10,890 square feet or less of buffer area.)

For every 400 square-foot unit (20'x20') or fraction thereof, plant:

one (1) canopy tree @ 1½" - 2" caliper or large evergreen @ 6'
two (2) understory trees @ ¾" – 1 ½" caliper or evergreen @ 4'
or *one* (1) understory tree and *two* (2) large shrubs @ 3'-4'
three (3) small shrubs or woody groundcover @ 15" – 18"

Example:
A 100-foot wide lot x 100-foot wide buffer is 10,000 square feet.
Divide by 400 square feet (20'x20' unit) to get:
25 units

Units	x	plant/unit	Number of plants
25 units	x	1 canopy tree	25 canopy trees
		2 understory trees	50 understory trees
		3 small shrubs	75 small shrubs
			150 plants

RESTORATION/ESTABLISHMENT TABLE B

Greater than ¼ acre of buffer

More than 10,890 square feet

A. Plant at the same rate as for ¼ acre or less.

B. <u>The waterside 50% of the buffer (from the waterline inland for the first 50 feet):</u>
For every 400 square-foot unit (20'x20') or fraction thereof plant:

one (1) canopy tree @ 1½" - 2" caliper or large evergreen @ 6'
two (2) understory trees @ ¾" – 1 ½" caliper or evergreen @ 4'
or *one* (1) understory tree and *two* (2) large shrubs @ 3'-4'
three (3) small shrubs or woody groundcover @ 15" – 18"
<u>AND</u>

<u>The landward 50% of buffer (from 50 feet inland to 100 feet inland):</u>
either plant
Bare root seedlings or whips at 1,210 stems per acre[1] , approximately 6'x6' on center (Minimum survival required after two growing seasons: 600 plants)
or
Container grown seedling tubes at 700 per acre approximately 8'x 8' on center (Minimum survival required after two growing seasons: 490 plants)

C. If the applicant is willing to enter into a five year maintenance and performance guarantee:
100% of buffer planted with:
Bare root seedlings or whips at 1,210 per acre, approximately 6'x 6' on center (Minimum survival required after two growing seasons: 600 plants)
Or
Container grown seedling tubes at 700 per acre approximately 8'x 8' on center (Minimum survival required after two growing seasons: 490 plants).

1 acre or more of buffer

With an evaluation from an arborist or forester or other professional, natural regeneration may be an acceptable method of buffer establishment, however, a forestry management plan must be in place prior to any vegetation being removed. A minimum of 35 feet next to the water must be left in forest and protected prior to any vegetation being removed. If over 20 percent of the vegetation must be removed for the health of the woodlot, within the 35 feet closest to the shore-line, vegetation must be reestablished by seedling plantings at the rates above.

[1] Palone, Roxanne S., and Al Todd, *Chesapeake Bay riparian handbook: A guide for establishing and maintaining riparian forest buffers.* May 1977. p. 7-20.

invasives that the original underlying vegetation is unknown, part A of the Restoration Table is recommended as a reference to determine replacement amounts. Replacement planting plans should include a maintenance schedule. Some local governments have the authority to require performance guarantees, and as a matter of practice require them to assure survivability of the plants. The scientific literature suggests that two years may be needed to assure plant survival.

Reestablishment of a buffer must occur when a parcel of land that was in either agricultural or silvicultural use is converted to another use. Part B of the Restoration Table is a recommended reference for reestablishing the 100-foot wide buffer. Alternatively, a regeneration plan may be prepared by an arborist or other qualified professional.

For areas over one (1) acre that have been evaluated by a professional and meet the criteria, natural regeneration may be allowed according to the procedure outlined in the following section.

NATURAL REGENERATION

If regeneration is the desired method of reforestation on a parcel that is currently in silvicultural use, but will change to another use after timber harvesting, a reforestation plan must be in place prior to the timber being cut. This will allow the assessment by a trained forestry professional to evaluate the regeneration capability of the buffer areas and suggest the best timber harvesting methods to produce that result. They will also be able to assist in developing a plan for the appropriate site preparation for hardwood establishment after timber harvest.

PLANTING SEASON

The best time for planting trees and shrubs is the spring or fall while the plants are dormant. The preferred time for deciduous species is spring, (late February / early March to May1st before bud break). Fall planting can take place after the leaves have fallen off deciduous plant material. Generally, evergreen plant material can be planted during the same period of time, although their dormancy period is a bit shorter. However, fall plantings should be well watered and mulched to prevent winter desiccation. Frozen ground is the major obstacle to planting during the winter months.

MAINTENANCE

Maintenance of a newly planted buffer is necessary to assure survival of the vegetation. Included in that is the need to control invasive species, grasses and vines. These need to be kept away from new plantings by mulch, geo-textiles, mechanical means, chemical application, tree shelters or other means as necessary until the plantings are established. The ground around and between the plantings requires cover to prevent erosion. Native plants should be well adapted to the area and require no additional fertilization. The area should have signs or fencing to prevent mowing within the buffer while the new plantings establish and volunteer vegetation germinates from seed or sprouts from remaining roots.

A maintenance schedule should outline the timing and methods for maintenance activities, from watering to control of competing vegetation. The second most important issue related to the success of the planting is "…the care the plantings receive during the first year, watering at regular intervals being especially important."[11]

Over time as volunteer plant materials enter the buffer, thinning or removal of undesirable and invasive species may be necessary to assure the health of the buffer. A professional arborist or forester should include a maintenance plan in his/her forest management plan or forest stewardship plan.

Some local governments that have the authority to require performance guarantees to assure the survivability of the plantings, may choose to require such a guarantee. Research suggests that, generally, the larger sized replacement plantings should be established within one growing season. For restoration or regeneration planting, a minimum of two years or, more realistically, five years may be necessary to evaluate the survival rate of the plantings.

CONCLUSIONS

When reestablishing a woody buffer the following criteria should be met:

- The hydrology of the site should be evaluated and necessary measures taken to assure the dispersal of concentrated flows into sheet flow before runoff reaches the riparian buffer area.
- Best management practices for erosion and sediment control should be employed during restoration activities

to protect adjacent wetlands and shorelines of water bodies.

- Site preparation shall be sufficient for the establishment and growth of the selected plants and done at a time to insure their survival and growth.
- Plant stock should come from properly certified and inspected nurseries.
- Species planted should be non-exotic strains of native plants, (non-hybrid, non-invasive), indigenous to the area, and adapted to the site conditions.
- The mix of species chosen should reflect the ecological community in adjacent or nearby parcels following the composition and mix of trophic layers.
- A mixture of container grown or B&B species with no less than 1 canopy, 2 understory, and 3 shrub species per 400 square feet, is recommended for a buffer restoration site of a quarter of an acre (10,890 square feet) or less.
- The location and density of the plants should complement the natural features of the site. Random spacing and clustered groups of mixed species should be used rather than evenly spaced rows of plants.
- Mulching, tree shelters (at a rate of 100 per acre), grass mats, or other methods should be used where necessary to ensure the survival of the selected plant material.

[1] Virginia Department of Forestry. (July 2002). *Virginia's Forestry Best Management Practices for Water Quality.* Fourth Edition. Charlottesville, VA.: Department of Forestry. p. 44.

[2] Harker, et.al. *Landscape Restoration Handbook*. New York Audubon Society. Lewis Publishers. p. 66.

[3] Palone, R. S. & Todd, A. H. eds. (1997). *Chesapeake Bay Riparian Handbook: A Guide for Establishing and Maintaining Riparian Forest Buffers*. USDA Forest Service. NA-TP-02-97. Radnor, PA. p. 6-5.

[4] Palone, p 6-5.

[5] Palone, p 6-5.

[6] Virginia Department of Forestry. *Watershed Management*. Online. Internet.

[7] Palone, p.6-3.

[8] DCR – Division of Natural Heritage. (2002). Unpublished data on stand structure and stocking in forests of estuarine and riparian buffers.

[9] Alliance for the Chesapeake Bay. (January 1996). *Riparian forest buffers.* White Paper.

[10] Schueler, Thomas. (1987) *Controlling urban runoff: A practical manual for planning and designing urban BMPs*. Washington, D.C.: Metropolitan Washington Council of Governments, in *The Chesapeake Bay Local Assistance Manual*, (1989). p.IV-56.

[11] Harker, et.al. p. 67.